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Vernal Pools are at Home on the Range

Vernal pools are among the rarest of California's scarce but ecologically vital wetland resources. Although conventional wisdom suggests that preserving these areas requires leaving them untouched, new research indicates that nearby cattle grazing actually may benefit the fragile wetlands.

BY JAYMEE MARTY

Livestock grazing in the American West often conjures up images of cattle degrading riparian areas or spreading cheatgrass throughout a desert rangeland. Livestock's bad reputation among environmentalists is understandable: the popular press and scientific literature frequently detail the negative impacts of grazing on sensitive western areas.[1] Given less attention is the important fact that cattle grazing does not always or necessarily harm biodiversity. In fact, livestock activity may in some cases benefit valuable wetlands.

Several studies have shown that livestock grazing can help reduce the cover of invasive non-native species.[2] Additionally, in areas where native herbivores have been eliminated (often thanks to human disturbances), livestock grazing may replicate ecological disturbance processes vital to local ecosystems and thereby help prevent the loss of species dependent on those processes.[3] For years, ecologists in California have reported anecdotal accounts of wildflower displays diminishing when proximate grazing activity was halted.

These findings inspired ecologists studying California's vernal pools, seasonally inundated wetlands that occur throughout the state's Central Valley on poorly drained soils and provide unique habitat for many endemic plants and invertebrates, to hypothesize that grazing actually helps maintain plant diversity in vernal pool grasslands. This idea persisted for years, but until recently, the hypothesis had not been tested—even though the possibility that grazing might benefit vernal pool systems should be a key issue for range managers. In 2000, researchers at the Cosumnes River Preserve, a cooperative partnership of landowners in California dedicated to the preservation of the Cosumnes River watershed, the only undammed river on the Sierra Nevada's western slope, began an experiment examining the role cattle grazing plays in the maintenance of plant and animal diversity in vernal pools and their surrounding grassland matrix.

CALIFORNIA'S UNIQUE GRASSLAND ECOSYSTEMS

California's grasslands are a distinctive combination of anthropogenically altered uplands and rare, intact wetlands. Decades of ranching, agricultural use, and extended drought periods have nearly converted the state's dry uplands from perennial bunchgrass-dominated grasslands to an annual system dominated by grasses and forbs, broad leaf

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flowering plants native to Europe's Mediterranean region.[4] Within these invaded and converted grasslands, however, lie vernal pools, small wetlands that are havens for a diverse native flora and an array of unique aquatic fauna. These pools are inundated during the winter and slowly dry during the spring.

Experimenting with Grazing Treatments

The majority of California's upland grasslands are currently and have been historically grazed by livestock. As vernal pool land is acquired for conservation purposes, land managers often question whether removing grazing completely or seasonally would benefit these sensitive areas. To address this question for California's vernal pool systems, our researchers constructed livestock exclosures around groups of vernal pools. We tested the impact of four grazing treatments, replicated our treatments across two major soil types (Gillender and Corning soils), and included a wide range of vernal pool sizes (from 70 to 1,130 square meters) and shapes in the experiment. In this article I will discuss two of the treatments: a regime replicating historical grazing conditions with pools continuously grazed from October through June (the control treatment), and complete removal of grazing (that is, vernal pools completely fenced throughout the year). We established 6 replicates of our treatments at 36 vernal pools located across an approximately 12,362-acre site in eastern Sacramento County.

The researchers measured pool hydrology by recording water depths in each pool on a weekly basis throughout the winter rainy season. In January and March we sampled the aquatic invertebrates in all pools that held sufficient water. Ten percent of the area of each pool was sampled by sweeping a dipnet as close to the pool bottom as possible along randomly located transects. After surveying each sample for threatened and endangered species, we preserved the sample contents in 70 percent isopropyl alcohol. Samples were stored at room temperature until they could be sorted and taxa identified to the lowest taxonomic level.

In the first year of the experiment, we established and permanently marked quadrats measuring 35 by 70 centimeter along three transects for each pool in three different pool zones: the deepest part of the pool, the edge of the pool (selected in the first year based on the high water mark), and the upland area 5 meters from the adjacent edge quadrat. We recorded plant species composition annually in each pool after the pools had dried and the majority of the plant species were flowering, generally in April or May. We assigned each plant species a cover class value[5] and used these values to calculate percent of vegetative cover. The research team evaluated the significance of differences for each variable with a two-way nested analysis of variance.

Grazing Maintains Diversity and Hydrology in Vernal Pools

After just three years, the ungrazed vernal pools became overgrown with non-native vegetation. Both plant and invertebrate species richness declined in these treatment areas, and the pools were inundated for shorter time periods relative to the pools grazed at historic levels. These effects were so dramatic that they were readily apparent without any sampling. We observed declines in relative cover of native plant species of 20 to 50 percent at both pool edges and in upland areas, concomitant with an increase in exotic grass cover in the ungrazed pools and their associated upland zones. The overall species composition in these pools shifted to a dominance by grasses. Perhaps the most important treatment effect was an overall decline in native species richness per quadrat in the edge and upland zones of the ungrazed pools versus a net increase in richness in the continuously grazed pools.

The hydrology of the ungrazed pools changed significantly over the three years of the experiment. In 2003, the pools that were ungrazed had an average maximum inundation period of 65 days, plus or minus 8 days, whereas the continuously grazed pools were inundated for a maximum of 115 days, plus or minus 9 days. In addition to this reduction in the inundation period, the ungrazed pools dried and refilled an average of twice per season, while the continuously grazed pools dried fewer than once per season on average. Invertebrate taxa richness was negatively affected by these hydrologic changes: by the third year, taxa richness was approximately 20 percent lower in the ungrazed treatment group than in the continuously grazed control group.

Analyzing Results

These results support the hypothesis that grazing is an important disturbance in vernal pool grasslands. In our study, cattle clearly were capable of preventing exotic grasses from dominating the vegetation around the pools. This finding complements other studies of California grasslands that have documented the capacity of exotic annual grasses to dominate vegetative systems unless grazing or some other form of disturbance is present.[6] Pool edges and upland habitats are even more vulnerable than pool basins to invasion by exotics, and it is not surprising that the vegetation along the pool edges and in the uplands was most affected by the removal of grazing.

The primary reason for the dramatic shift in hydrology in the ungrazed pools may be an increase in evapotranspiration rates associated with the abundance of vegetation, principally grasses, in and around those pools. This hypothesis is supported by studies from the Midwest that have documented higher evapotranspiration rates in ungrazed grasslands relative to grazed grasslands.[7] The pattern of water depths for 2003 in our pools also supports this hypothesis. The depths of the grazed and ungrazed pools were similar during the initial inundation period, but sharply diverged once the primary vegetation growth period began in early March: the ungrazed pools experienced sharp declines in depth, quickly followed by complete drying.

This shift in hydrology has important implications for species that inhabit vernal pools. Most importantly, the decreased inundation period in ungrazed pools may not support the long reproductive cycles of some rare invertebrate and vertebrate species that depend on the pools. For example, the California tiger salamander (*Ambystoma californiense*) requires a continuous inundation period of 70 to 90 days to complete metamorphosis.[8] The ungrazed pools in our study clearly could not provide suitable salamander habitat. The altered hydrology also probably is responsible for the low invertebrate taxa richness in the study's ungrazed pools relative to the grazed pools. This low richness probably resulted from the higher number of drying periods in the ungrazed pools. The invertebrate communities in both groups of pools developed quickly, reaching maximum taxa richness approximately six weeks after first inundation. However, each time a vernal pool dries and refills, the invertebrate adults either die or leave

the pool. Thus, invertebrate community development in the ungrazed pools was arrested multiple times per season, whereas the communities in the continuously grazed pools had sufficient time to develop and presumably support the successful growth and reproduction of longer-lived taxa.

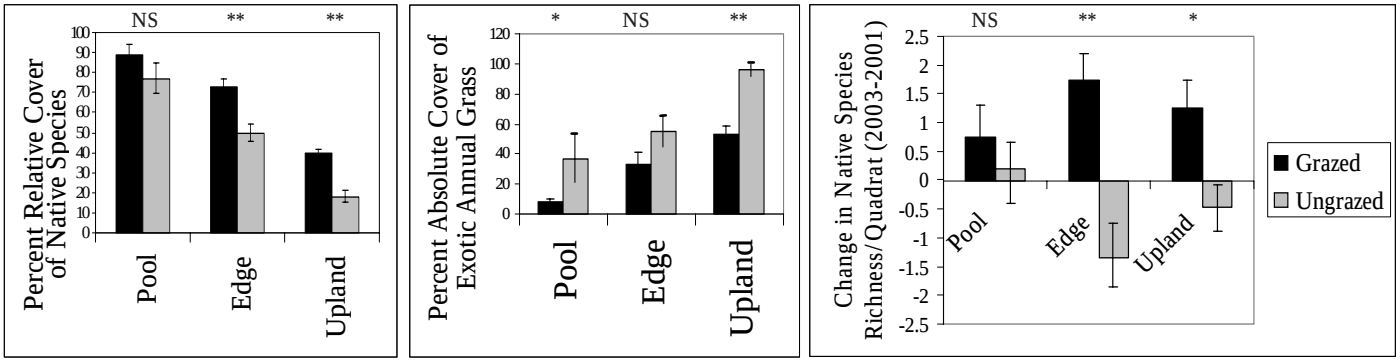
Nurture Better Than Nature? Explaining Surprising Results

These experimental results raise an important question: How did diverse vernal pool flora and fauna exist and thrive prior to cattle introduction? Of course, tule elk and pronghorn grazed the Central Valley grasslands prior to the introduction of domestic livestock; this implies that vernal pools already were adapted to some level of grazing—but herds of elk and pronghorn grazed differently than today's cattle. Essentially, the entire ecology of the current California grassland system is very different from the system that existed prior to livestock introduction approximately 150 years ago. Specifically, prior to European settlement, the Central Valley had a completely different plant species composition. Cattle introduced by settlers may have fundamentally altered vernal pool morphology by compacting soil and changing basin shapes and depths by repeated visitation during wet seasons. The result is a grassland system adapted to the impacts of livestock grazing that now declines without regular cattle disturbance.

Analytical Limitations and Call for Further Research

Although this study provides important information regarding grazing in and around vernal pools, we need to be clear about its limitations. First, although we plan to continue the study for several years, it is still a relatively short-term study of a system driven by rainfall and temperature regimes. Continued data collection will allow us to better understand the ways in which grazing and interannual climatic variation interact to affect vernal pool systems. Second, this study was conducted at one area in Sacramento County with one grazing history and a single stocking rate. Although we manipulated grazing intensity and severity by fencing off pools, we cannot say for certain whether the study's results could be replicated at a site with a different grazing history, different types of livestock, or different stocking rates; however, years of anecdotal evidence gathered throughout the state suggests that such replication would be possible. Finally, vernal pools occur across diverse climatic and soil settings in California. Although our results were robust across a wide range of pool sizes and two soil types, similar studies should be conducted at other sites in the state to test whether these results hold across a diversity of pool conditions.

All field experiments in ecology or resource management are limited by their specific timeframes and locales. These limitations in no way make their findings unimportant. Our research found that livestock grazing clearly plays an important role in maintaining species diversity in the vernal pool grasslands we studied. We observed that grazing removal had significant negative effects on the pools' native plant communities, hydrology, and aquatic invertebrate communities. Clearly, grazing should be considered a potentially positive force for the maintenance of biodiversity in some situations. Instead of inflexibly labeling grazing as an environmental stressor, environmentalists and the public should realize that the impact of cattle on wildlife depends on a variety of factors, and then conduct or support the research and studies necessary to figure out exactly how those factors interplay. ■



The notations: NS = not significant, * = significant at the P<0.05 level, and ** = significant at the P<0.01 level. All graphs are courtesy of J. Marty.

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